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Naruishi et al.

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(54) **IMPACT DETECTOR AND PACKAGING CONTAINER**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 377 days.

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G08B 21/00 (2006.01)

(52) **U.S. Cl.**
USPC **340/665; 340/669; 340/673**

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

An impact detector includes a weight having a circular periphery, a case in which the weight is contained, an interior of which defines a transition path that connects an initial position and an impact detection position, and a restriction portion projecting from the interior of the case into the transition path. The weight moves through the transition path to the impact detection position with a circumferential surface of the weight in contact with the interior of the case when the case receives an impact in a predetermined direction, and the restriction portion restricts movement of the weight toward the impact detection position when the case receives impact in a direction other than the predetermined direction.

14 Claims, 12 Drawing Sheets

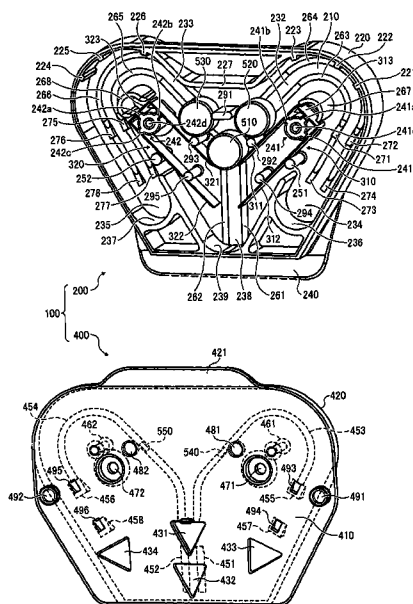


FIG. 1

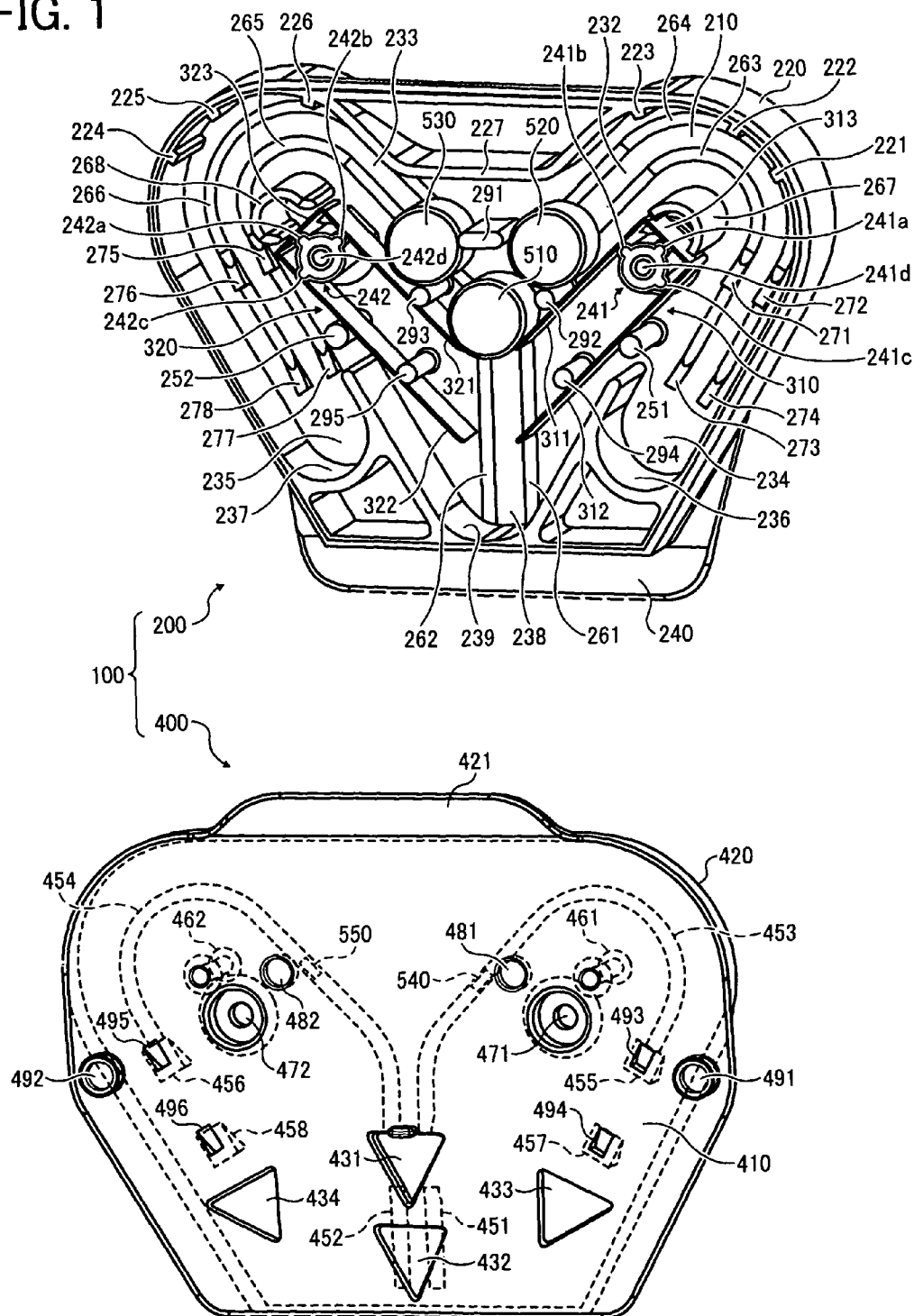


FIG. 2

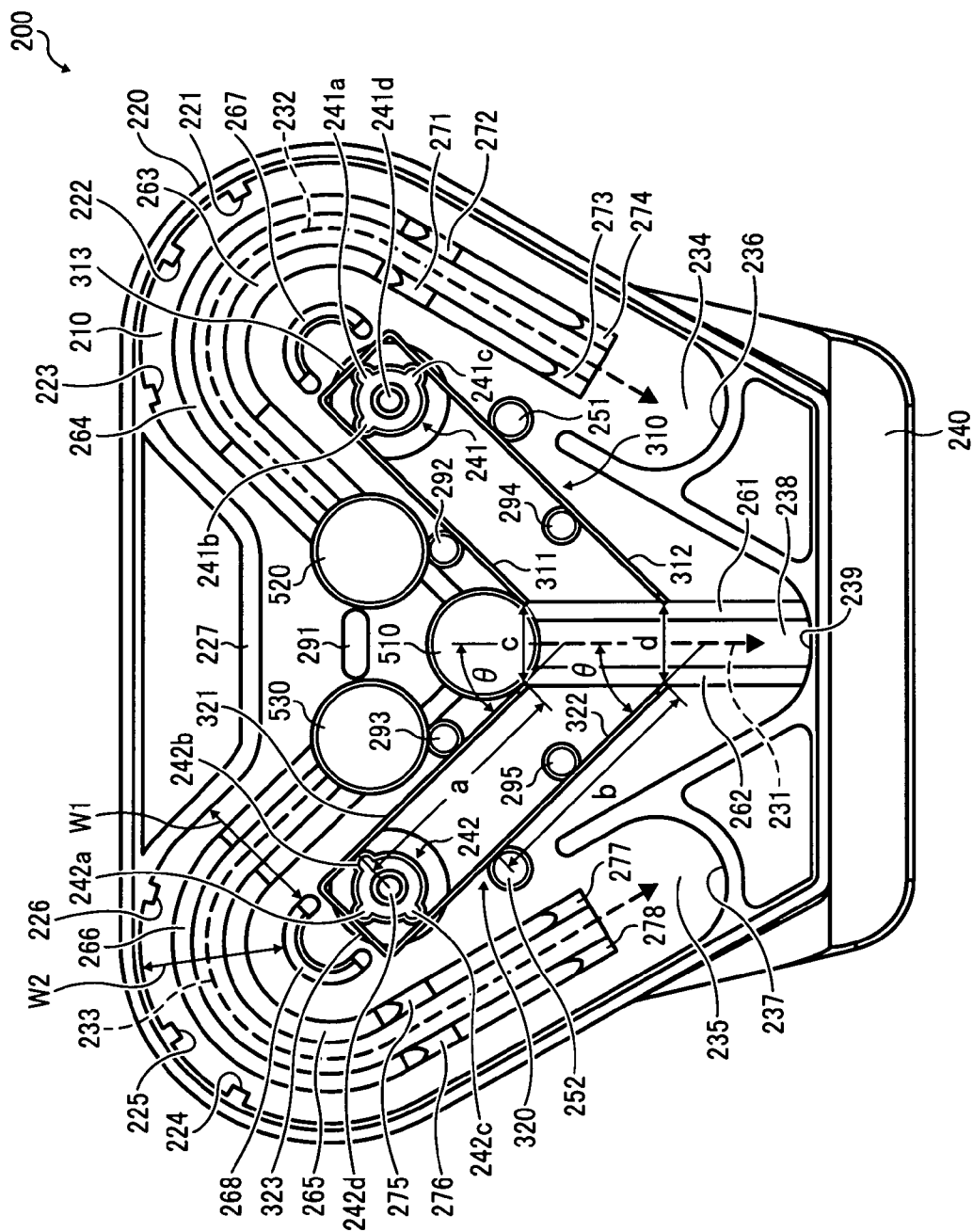


FIG. 3

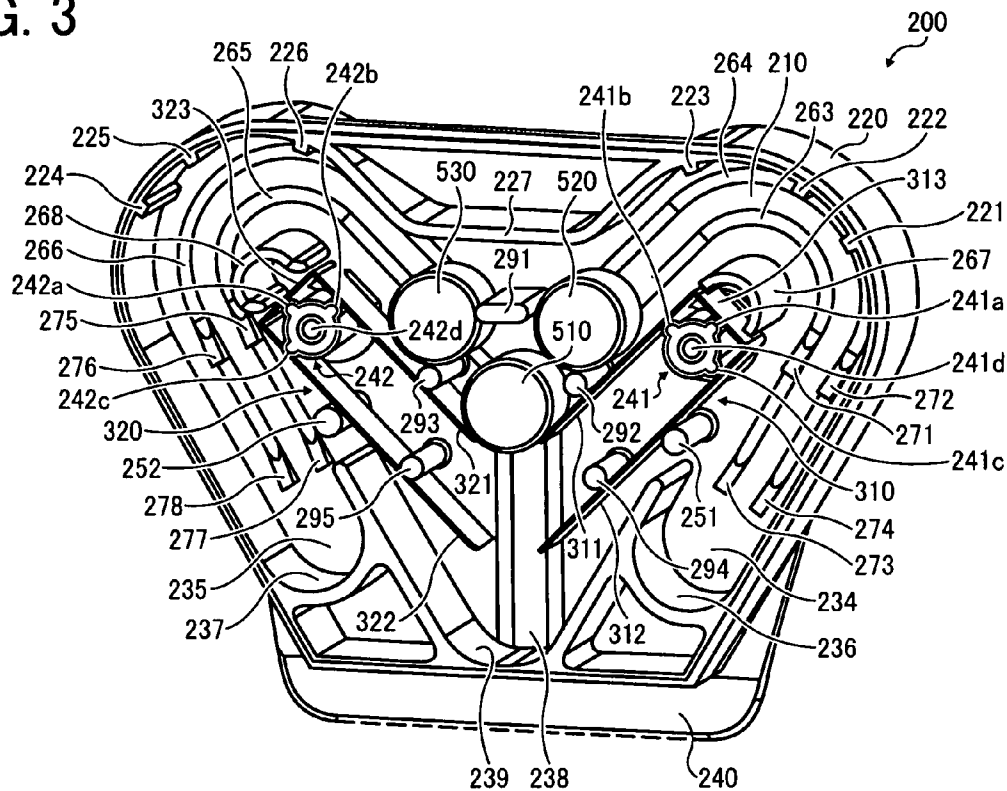


FIG. 4

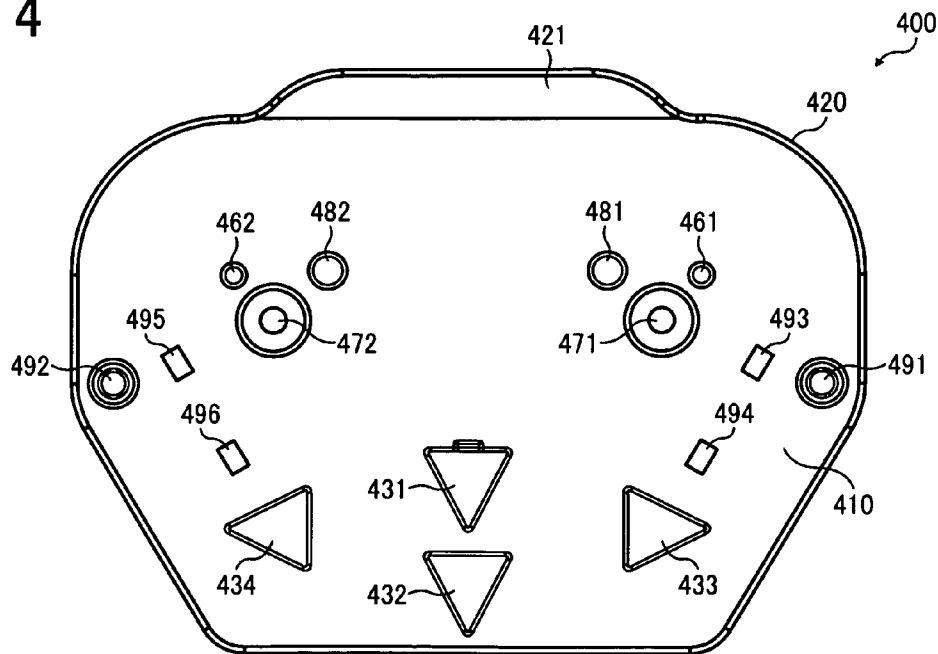


FIG. 5

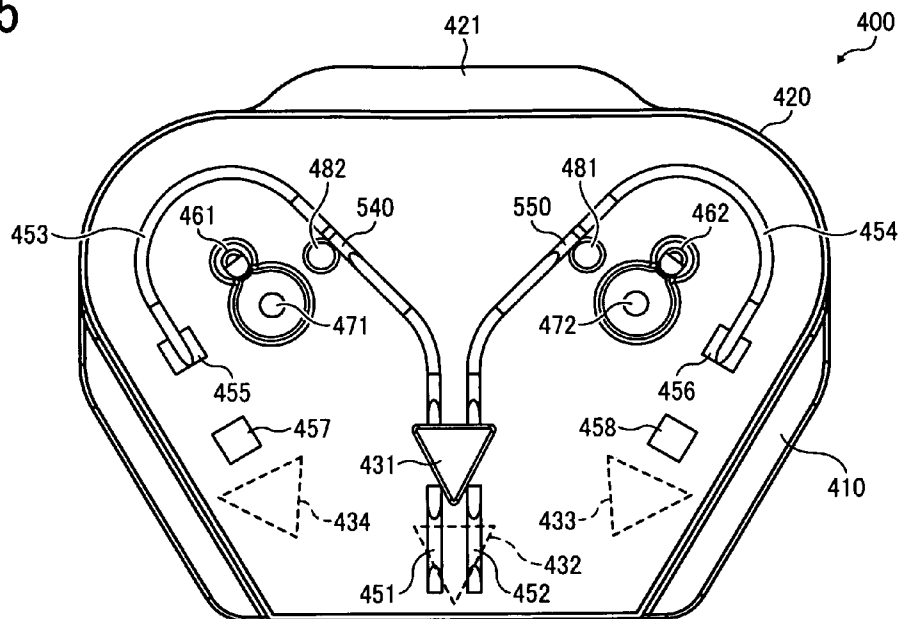


FIG. 6

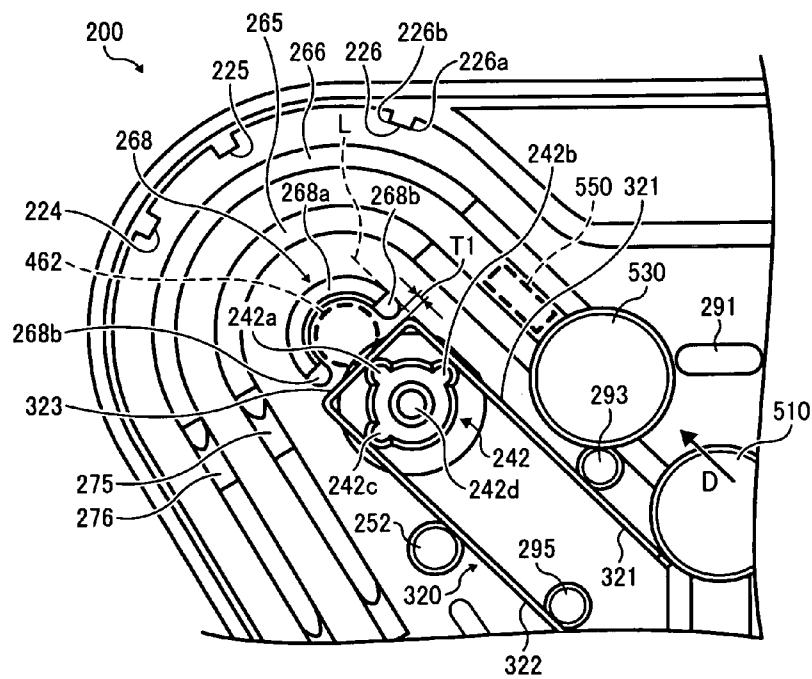


FIG. 7

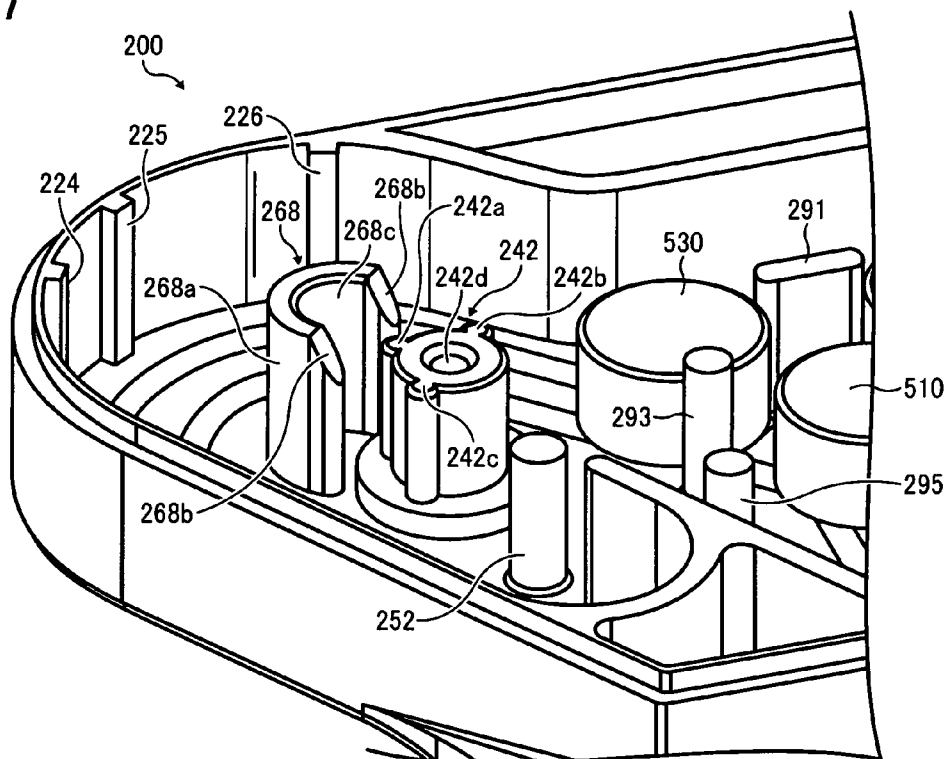


FIG. 8

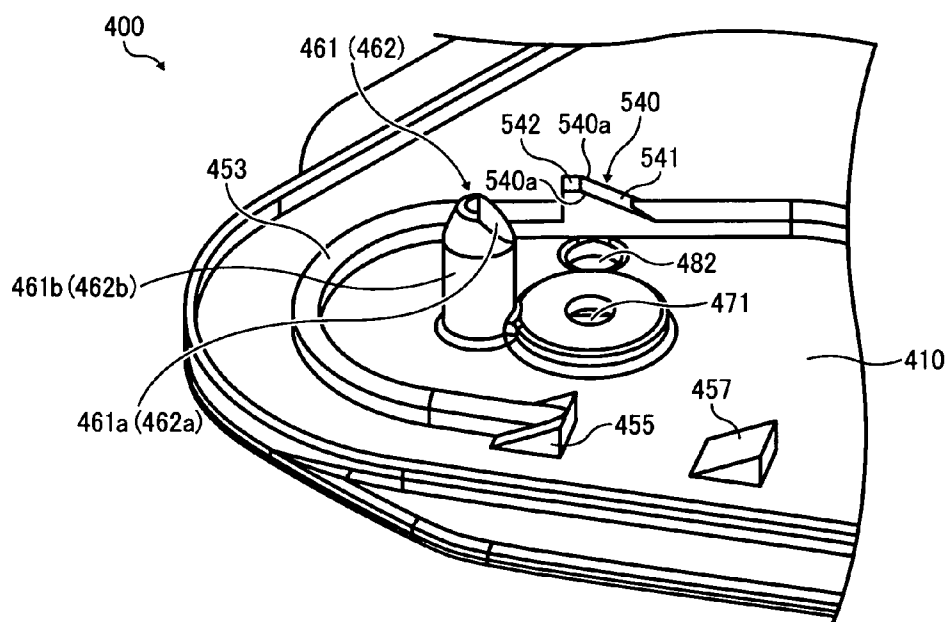


FIG. 9

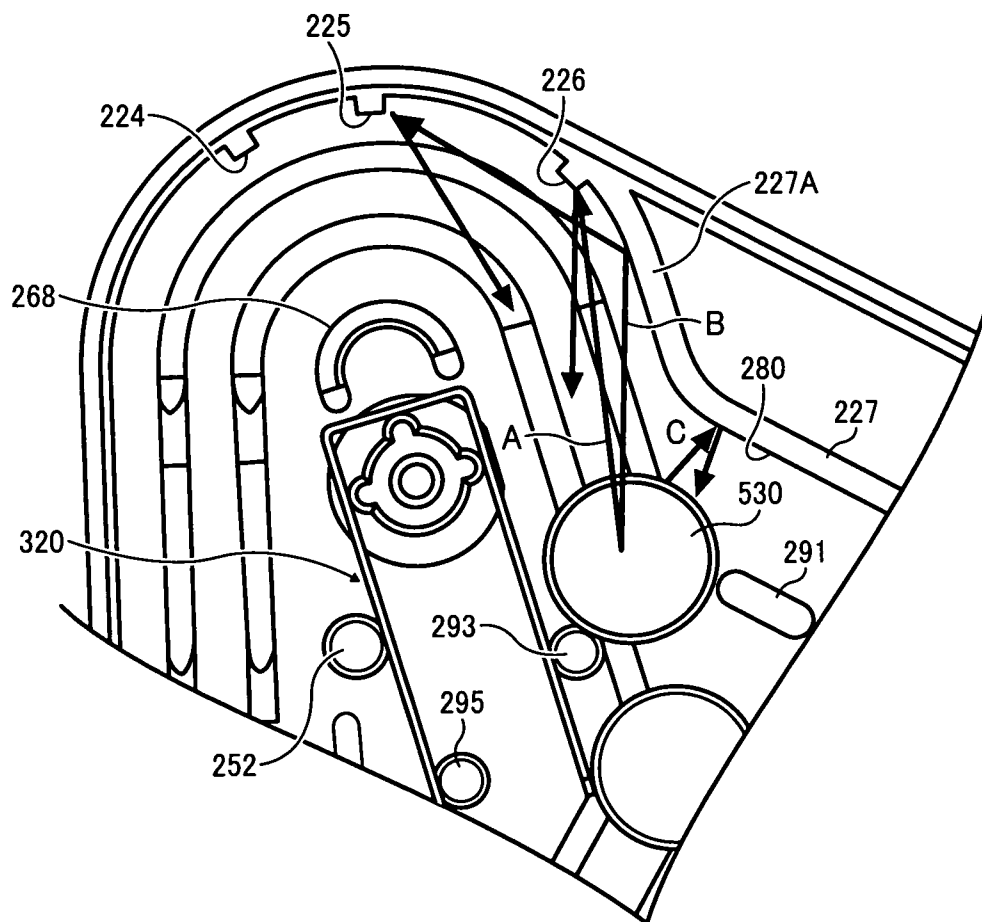


FIG. 10A

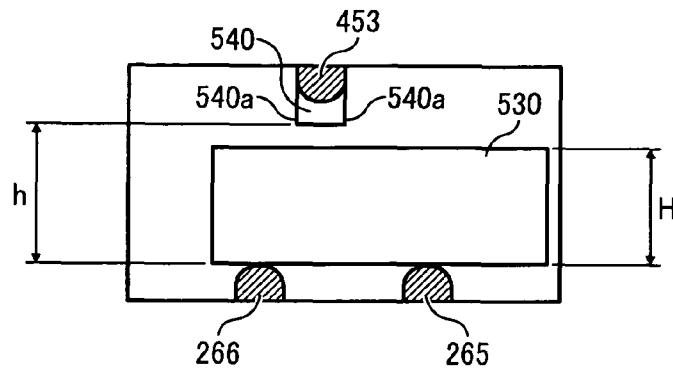


FIG. 10B

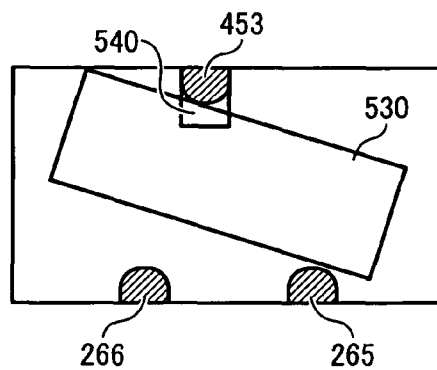


FIG. 10C

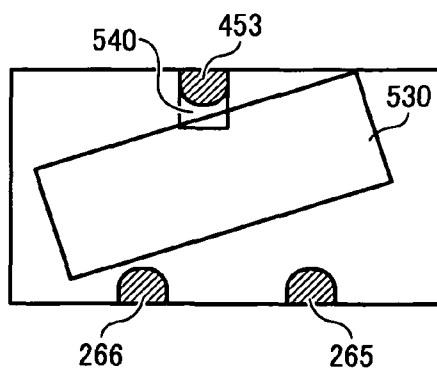


FIG. 11A

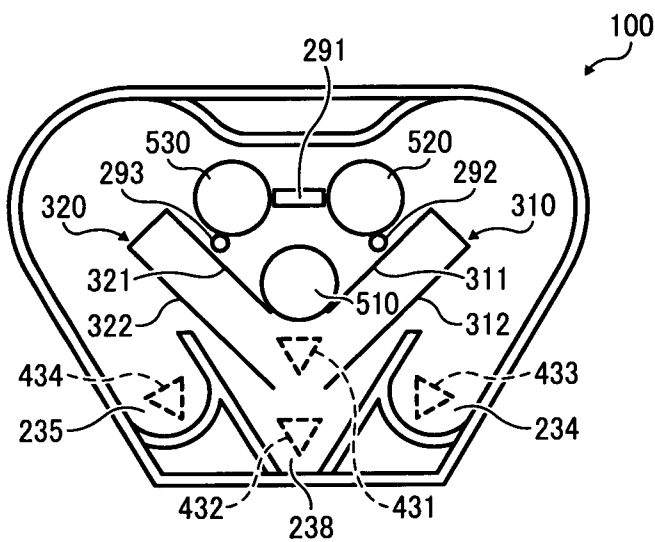


FIG. 11B

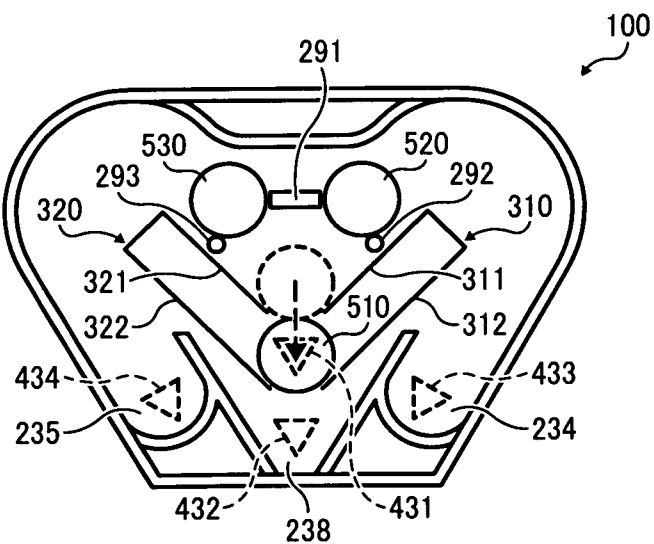


FIG. 11C

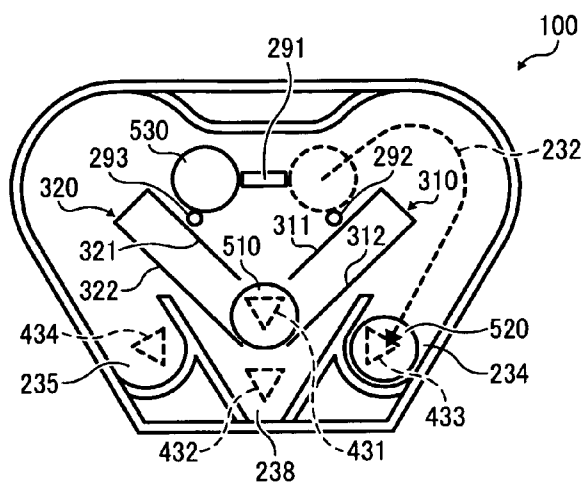


FIG. 11D

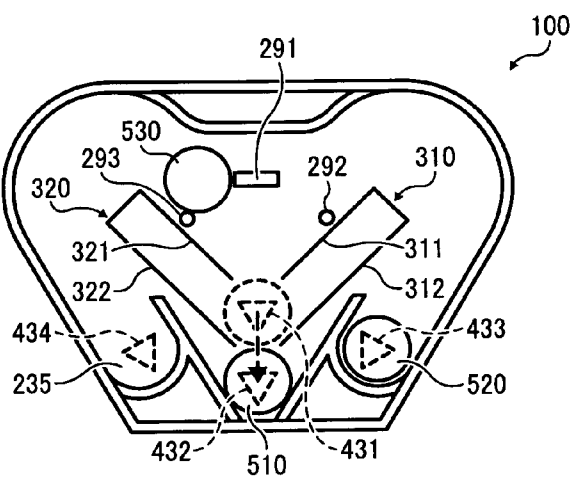


FIG. 11E

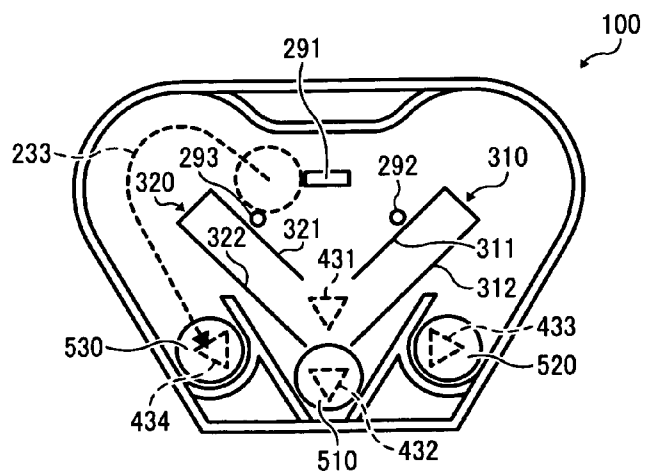


FIG. 12A

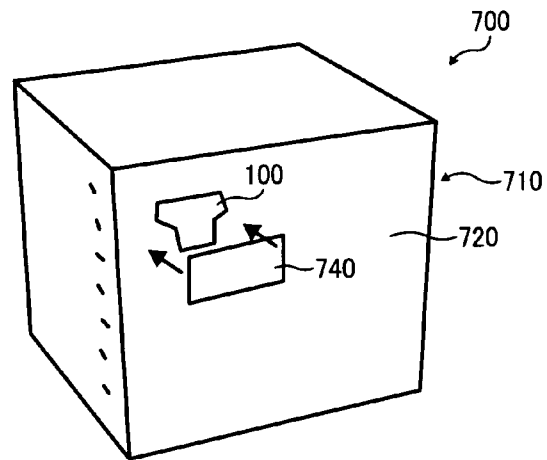


FIG. 12B

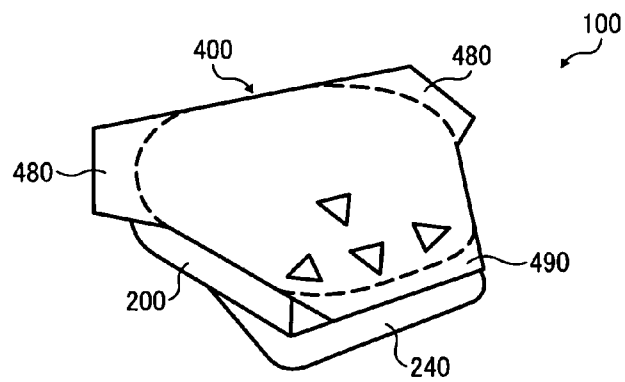


FIG. 12C

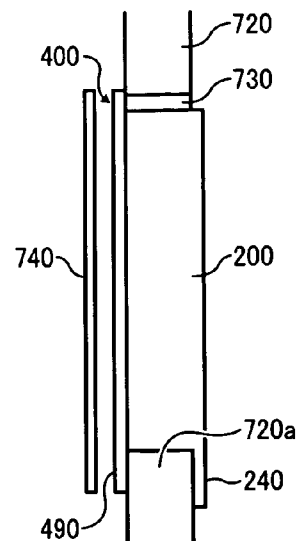


FIG. 13

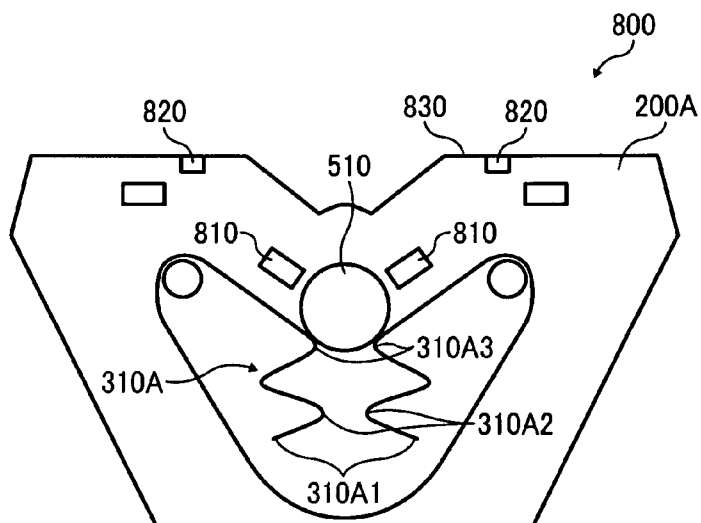


FIG. 14

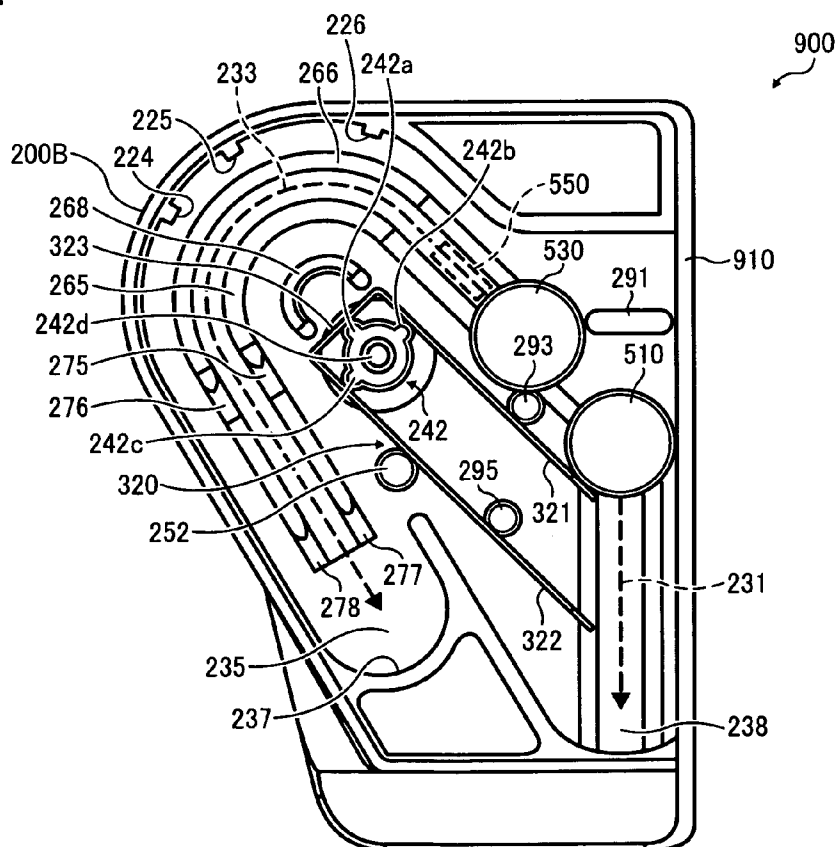


FIG. 15

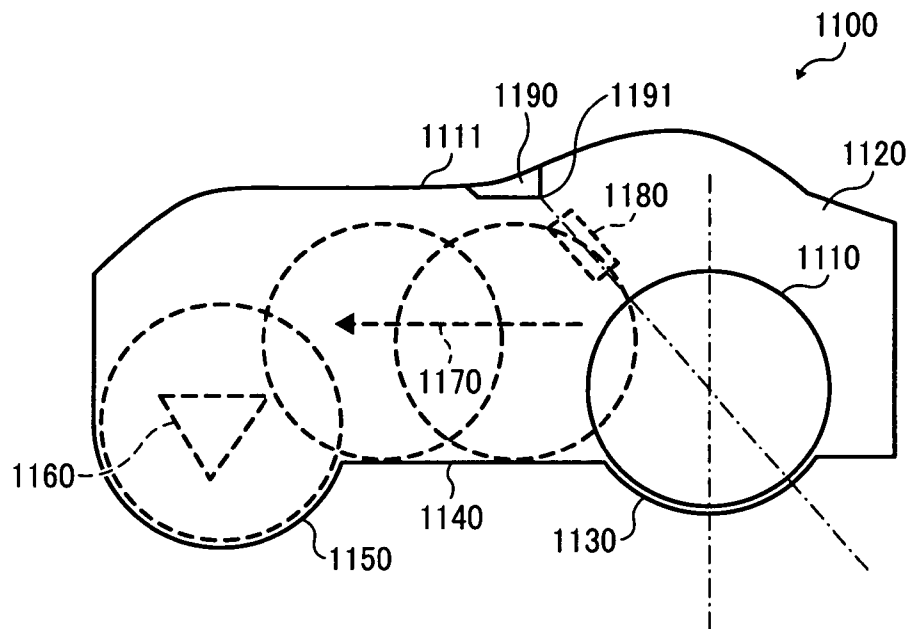
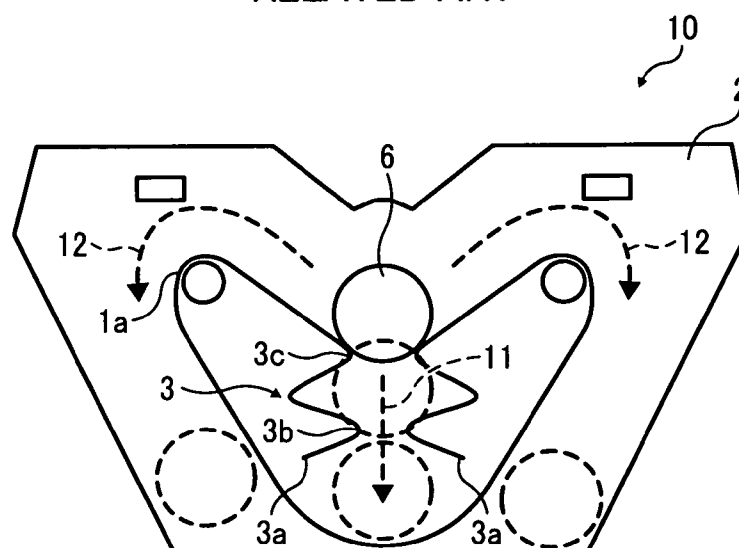


FIG. 16
RELATED ART



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IMPACT DETECTOR AND PACKAGING CONTAINER

CROSS REFERENCE TO RELATED APPLICATIONS

The present specification is based on and claims priority pursuant to 35 U.S.C. §119 from Japanese Patent Application No. 2009-238887, filed on Oct. 16, 2009 in the Japan Patent Office, which is hereby incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an impact detector to detect impact to an article and a packaging container including the impact detector.

2. Description of the Background Art

In the course of transport, it sometimes happens that fragile packaged articles such as precision equipment fall or are dropped due to inappropriate handling, accidents, or the like. The impact of the fall or drop can damage the articles. For this reason, therefore, impact detectors are typically attached to packaged articles to detect whether or not the article has been subjected to impact.

For example, JP-2009-156726-A discloses an impact detector shown in FIG. 16. Referring to FIG. 16, an impact detector 10 is for detecting impact of fall or drop of a packaged article. The impact detector 10 includes a leaf spring 3 and a weight 6, both disposed inside a case 2. The interior of the case 2 and the leaf spring 3 together form a vertical transition path 11, through which the weight 6 moves down when the case 2 is subjected to an impact in a vertical direction as well as lateral transition paths 12 through which the weight 6 moves when the case is subjected to an impact in a direction oblique to the vertical direction. In this known impact detector 10, the leaf spring 3 includes free ends 3a and projections 3b and 3c so that the position of the weight 6 in the vertical transition path 11 can differ depending on the magnitude of the impact. Thus, the impact detector 10 displays an impact history with the position of the weight 6.

In the impact detector 10, when the impact in the vertical direction, that is, the impact from below is relatively small, the weight 6 does not push away the upper projections 3c of the leaf spring 3 from each other and remains at an initial position indicated by a solid line. By contrast, when the impact from below is sufficiently great for the weight 6 to push away the projections 3c from each other, the weight 6 expands the gap between the projections 3c, moves down, and then is caught between the lower projections 3b. When the impact is greater, the weight 6 pushes away the lower projections 3b from each other and moves down to the bottom of the case 2. At that position, the weight 6 is visible through an inspection window formed in a bottom portion of the case 2. Additionally, with the projections 3b, the weight 6 does not move toward the initial position. By contrast, when the packaged article falls in a lateral direction, the weight 6 moves through the lateral transition path 12, beyond a curved portion 1a of the leaf spring 3, and stops below and to the side of the leaf spring 3 in FIG. 16. Thus, the known impact detector 10 detects impact (external force) on the package article in multiple different directions, that is, lateral fall and drop of the packaged article, and provides a record (history) of the impact distinguishable in multiple different directions.

Although the impact detector 10 is configured to detect both the drop and lateral fall of the packaged article and to

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guide the weight 6 to different positions depending on the type (magnitude and direction) of the impact, it is possible that a complicated combination of magnitude and twist of the external force can generate false reading by the impact detector 10. In other words, it is possible that the weight 6 moves through the lateral transition path 12 even when the packaged article has not fallen in the lateral direction.

In view of the foregoing, the inventors of the present inventions recognize that there is a need for a more accurate impact detector.

SUMMARY OF THE INVENTION

In view of the foregoing, one illustrative embodiment of the present invention provides an improved impact detector. The impact detector includes a weight having a circular periphery, a case in which the weight is contained, an interior of which defines a transition path that connects an initial position and an impact detection position, and a restriction portion projecting from the interior of the case into the transition path. The weight moves through the transition path to the impact detection position with a circumferential surface of the weight in contact with the interior of the case when the case receives an impact in a predetermined direction, and the restriction portion restricts movement of the weight toward the impact detection position when the case receives impact in a direction other than the predetermined direction.

In another illustrative embodiment, a packaging container includes a packaging container in which an article is contained and the above-described impact detector.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the advantages thereof are obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is an exploded perspective view illustrating an impact detector according to an illustrative embodiment of the present invention;

FIG. 2 is a plan view illustrating a rear case of the impact detector shown in FIG. 1;

FIG. 3 is a perspective view illustrating the rear case shown in FIG. 2;

FIG. 4 is a plan view illustrating a front side (outer side) of a front case of the impact detector shown in FIG. 1;

FIG. 5 is a plan view illustrating a back side (inner side) of the front case shown in FIG. 4;

FIG. 6 is an enlarged plan view illustrating projections formed in a transition path in the rear case;

FIG. 7 is an enlarged perspective view illustrating the projections formed in the transition path in the rear case;

FIG. 8 is an enlarged perspective view illustrating a pawl formed in the front case;

FIG. 9 is a schematic diagram illustrating reflex of a weight caused by the projections in the rear case;

FIGS. 10A through 10C are schematic diagrams illustrating the pawl viewed in the direction indicated by arrow D shown in FIG. 6.

FIGS. 11A through 11E schematically illustrate operation of the impact detector;

FIG. 12A is a schematic perspective view illustrating a packaging container including the impact detector;

FIG. 12B is a schematic perspective view illustrating the impact detector attached to the packaging container shown in FIG. 12A;

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FIG. 12C is a schematic cross-sectional view illustrating the impact detector 100 attached to the packaging container;

FIG. 13 is a schematic view illustrating an impact detector according to a second embodiment;

FIG. 14 is a plan view from a front side illustrating an impact detector according to a third embodiment;

FIG. 15 is a schematic view illustrating an impact detector according to a fourth embodiment; and

FIG. 16 schematically illustrates a related-art impact detector.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In describing the embodiments illustrated in the drawings, specific terminology is employed for the purpose of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so used, and it is to be understood that substitutions for each specific element can include any technical equivalents that operate in a similar manner.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, particularly to FIGS. 1 through 5, a first embodiment of the present invention will be described below.

It is to be noted that “displaying or providing impact history” in this specification simply means displaying falling events of a packaged article to which the impact detector is attached and does not mean showing the falling events chronologically.

FIG. 1 is an exploded perspective view illustrating an impact detector according to a first embodiment, and FIGS. 2 and 3 are respectively a plan view and a perspective view illustrating a rear case of the impact detector. FIGS. 4 and 5 are plan views respectively illustrating a front side (outer side) and a back side (inner side) of a front case of the impact detector.

Referring to FIG. 1, an impact detector 100 according to the first embodiment includes a rear case 200 and a front case 400 for covering a front side of the rear case 400; together forming a case that contains three weight, namely, a first weight 510, a second weight 520, and a third weight 530. The impact detector 100 detects vertical impact and displays history (record) of the vertical impact with the movement of the first weight 510. Further, the impact detector 100 detects rightward and left ward tilts or falls from an initial position (standing state) shown in FIG. 1 and displays history of the rightward and leftward tilts with the movement of the second weight 520 and the third weight 530, respectively. Thus, the impact detector 100 displays the history of drops, tilts, and falls of a packaging container (e.g., a cardboard box) that contains a fragile article such as an image forming apparatus to which the impact detector 100 is attached.

In the present embodiment, the first weight 510 is held by a right planar member 310 and a left planar member 320 (i.e., elastic planar members) and can detect impact from below, (drop impact) twice. The right planar member 310 is a single member including a first holding member 311 (first arm) positioned on an upper side and a second holding member 312 (second arm) positioned on a lower side, which are connected together by a folded portion 313. Similarly, the left planar member 320 is a single member including a first holding member 321 (first arm) positioned on an upper side and a second holding member 322 (second arm) positioned on a lower side, which are connected together by a folded portion 323. In the present embodiment, each of the right planar

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member 310 and the left planar member 320 is a single elastic thin plate made of stainless steel, for example, and is lateral U-shaped substantially.

At an initial position in a vertical transition path 231 (represented by broken arrow shown in a center lower portion in FIG. 2), the first weight 510 is supported on both sides by the first holding member 311 of the right planar member 310 and the first holding member 321 of the left planar member 320. With the first drop impact, the first weight 510 pushes the first holding members 311 and 321 away from each other, drops, and then is held by the second holding members 312 and 322. With the second drop impact, the first weight 510 pushes the second holding members 312 and 322 away from each other and then drops.

Further, with a tilt of the impact detector 100 to the right (rightward tilt), the second weight 520 rolls to the right on the upper side of the first holding member 311. With a tilt of the impact detector 100 to the left (leftward tilt), the third weight 530 rolls to the left on the upper side of the first holding member 321. With the above-described configuration, the impact detector 100 detects drop and displays it with the movement of the first weight 510, detects a rightward tilt and displays it with the movement of the second weight 520, and detects a leftward tilt and displays it with the movement of the third weight 530. In the present embodiment, the weights 510, 520, and 530 are circular plates like coins, each having a circumferential surface and two flat side surfaces, that is, substantially round and flat. The weights 510, 520, and 530 include metal have certain degree of weights.

The other components of the impact detector 100 will now be described below.

Referring to FIGS. 2 and 3, the rear case 200 can be made of a synthetic resin and includes a back plate 210 and a wall portion 220 standing vertically to the back plate 210 along the circumference of the back plate 210. The rear case 200 further includes, in addition to the vertically extending vertical transition path 231 through which the first weight 510 moves upon a drop impact, a curved right transition path 232 (represented by broken arrow shown on the right in FIG. 2) through which the second weight 520 moves and a curved left transition path 233 through which the third weight 530 moves (represented by broken arrow shown on the left in FIG. 2) disposed on both sides of the vertical transition path 231. The second and third weights 520 and 530 roll on the upper side of the first holding members 311 and 321, respectively, when moving through the right and left transition paths 232 and 233, and thus the right and left transition paths 232 and 233 include wall portions with which the weights 520 and 530 are in contact while moving through the right and left transition paths 232 and 233, respectively.

A right weight holding portion 234, a left weight holding portion 235, and a lower weight holding portion 238 are formed below the right transition path 232, the left transition path 233, and the vertical transition path 231, respectively. The right weight holding portion 234, the left weight holding portion 235, and the lower weight holding portion 238 are formed by rib members 236, 237, and 239, respectively, which stand on the back plate 210.

On the right and left of the vertical transition path 231, a first right supporting member 241 and a first left supporting member 242 having a predetermined shape and size stand on the back plate 210. The first right and left supporting members 241 and 242 serve as columnar members each having an irregular circumference. The first right supporting member 241 holds the folded portion 313 of the right planar member 310 fitted therein, and the first left supporting member 242 holds the folded portion 323 of the left planar member 320

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fitted therein. Further, an arc-shaped member **267** standing on the back plate **210** is provided above the outer side of the first right supporting member **241** to fix the right planar member **310**, and an arc-shaped member **268** standing on the back plate **210** is provided above the outer side of the first left supporting member **242** to fix the left planar member **320**. The first right supporting member **241**, the arc-shaped member **267**, and a pressing member **461** provided in the front case **400** together fix the right planar member **310** to the case. Similarly, the first left supporting member **242**, the arc-shaped member **268**, and a pressing member **461** provided in the front case **400** together fix the left planar member **320** to the case. The arc-shaped members **267** and **268** also serve as respective inner guide portions of the right transition path **232** and the left transition path **233**.

Further, a second right supporting member **251** and a second left supporting member **252** that stand on the back plate **210** are provided below the first right supporting member **241** and the first left supporting member **242**, respectively. The second right supporting member **251** and the second left supporting member **252** are smaller in diameter than the first right supporting member **241** and the first left supporting member **242**, respectively. The second right supporting member **251** and the second left supporting member **252** prevent rotation of the right planar member **310** and the left planar member **320**, respectively. The second right supporting member **251** and the second left supporting member **252** also serve as respective fulcrums on which the second holding member **312** forming the lower portion of the right planar member **310** and the second holding member **322** forming the lower portion of the left planar member **320** deform elastically.

Further, two vertical weight guide rails **261** and **262** are formed on the back plate **210** along the vertical transition path **231**, and the first weight **510** slides on the vertical weight guide rails **261** and **262**. That is, the vertical transition path **231** includes a wall with which the weight **510** is in contact when moving through the vertical transition path **231**. Thus, the first weight **510** can move through the vertical transition path **231** smoothly. Additionally, on the back plate **210**, right weight guide rails **263** and **264** are formed along the right transition path **232**, and left weight guide rails **265** and **266** are formed along the left transition path **233**. These weight guide rails and the back plate **210** are formed as a united single member. Further, to reduce the contact resistance between each weight guide rail and the corresponding weight, the weight guide rail is arc-shaped in a cross section on the side in contact with the weight.

Further, to prevent the reverse movement of the second and third weights **520** and **530**, on the back plate **210**, return prevention projections **271** and **273**, **272** and **274**, **275** and **277**, and **276** and **278** are formed at respective two locations of the right weight guide rails **263** and **264** and the left weight guide rails **265** and **266**. The rear case **200** further includes a stop plate **291** disposed in an upper portion of the rear case **200** in the drawings for preventing the first weight **510** from bouncing up, weight supporters **292** and **293** for supporting respective lower portions of the second weight **520** and the third weight **530**, and positioning members **294** and **295** for regulating respective upper positions of the second holding members **312** and **322**. These elements stand on the back plate **210**. Further, the wall portion **220** includes a horizontal portion **227** positioned above the stop plate **291**, in the proximity of the stop plate **291**.

Next, projections formed on the wall portion **220** for preventing the second weight **520** and the third weight **530** from bouncing up are described below with reference to FIGS. 2, 6, and 7. FIGS. 6 and 7 are respectively an enlarged plan view

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and an enlarged perspective view illustrating projections **221**, **222**, **223**, **224**, **225**, and **226** serving as restriction portions formed in the rear case.

The projections **221**, **222**, **223**, **224**, **225**, and **226** project from the inner surface of the wall portion **220** and are positioned in the upper portion of the wall portion **220**, above the right and left transition paths **232** and **233**, to prevent the second weight **520** or the third weight **530** from bouncing up and moving. Referring to FIG. 2, the projections **221**, **222**, **223**, **224**, **225**, and **226** are for narrowing a width **W2**, of the right and left transition paths **232** and **233**. The width **W2** is the length of the right and left transition paths **232** and **233** in the direction perpendicular to the thickness of the weights. In other words, the projections **221**, **222**, **223**, **224**, **225**, and **226** are for reducing the distance of the gap in the interior of the rear case **200** (i.e., the gap between the wall portion **220**, serving as an upper wall, and the arc-shaped member **267** or **268**, serving as a lower wall) sandwiching the circumference of the second weight **520** or the third weight **530** in the direction of diameter of the second weight **520** or the third weight **530**.

In the present embodiment, the width **W2** of the right and left transition paths **232** and **233** in portions along the outer circumference of the arc-shaped members **267** and **268**, respectively, are wider than a width **W1** of the right and left transition paths **232** and **233** in entrance portions thereof, thus facilitating passage of the second and third weights **520** and **530**. Additionally, the projections **221**, **222**, **223**, **224**, **225**, and **226** have a substantially similar shape, and, for example, the projection **223** includes corners **226a** and **226b**. Other projections **221**, **222**, **223**, **224**, and **225** have corners similarly. It is to be noted that the shape of the projections **221**, **222**, **223**, **224**, **225**, and **226** is not limited to the above-described shape but can be any given shape such as semicircular or shapes having irregular surfaces as long as it can reduce the width **W2** of the right and left transition paths **232** and **233**.

Reflex of the weights caused by the projections is described below with reference to FIG. 9 that illustrates a case in which the impact detector **100** receives an impact that causes the third weight **530** to bounce up.

It is to be noted that, in FIG. 9, reference numeral **280** represents an inner wall of the horizontal portion **227**, and reference character **227A** represents a guide wall that is continuous with the horizontal portion **227** and guides the third weight **530** from the initial position to the left transition path **233**. The guide wall **227A** is positioned upstream from the projection **226** in the direction in which the third weight **530** moves to the impact detection position when the case receives a left-side impact.

Referring to FIG. 9, when receiving such an impact, the third weight **530** bounces off the projection **226** as indicated by arrow A. Then, the third weight **530** bounces off the guide wall **227A** as well as the projection **225** as indicated by arrow B, and returns to the initial position. Thus, malfunction of the impact detector **100** caused by impact in directions that are not to be detected can be prevented.

For example, the impact detector **100** receives impact in directions that are not to be detected in the following case.

In the present embodiment, when the packaging container, such as a cardboard box, to which the impact detector **100** is attached is dropped vertically, the first weight **510** moves down and thus indicates occurrence of the impact. In such vertical drop, the second and third weights **520** and **530** might receive repulsion of the weight supporters **292** and **293**, respectively, and bounce up. Although the third weight **530** bounces off the inner wall **280** of the horizontal portion **227** as

indicated by arrow C to the initial position in vertical drops, if the cardboard box to which the impact detector 100 is attached is dropped in a position tilted to the right in the drawings or is dropped from its lower right corner, the third weight 530 might move through the transition path identical to that for leftward tilt or fall, which is not desirable. Therefore, the projections 221 through 226 are provided for returning the second weight 520 and the third weight 530 to the respective initial positions. Thus, detecting impact in directions not to be detected, that is, malfunction of the impact detector 100, can be prevented in the present embodiment.

The rear case 200 further includes a flange portion 240 extending downward, to be attached to a packaging container. The flange portion 240 is formed as an extension of the back plate 210. As described above, the rear case 200 has a line-symmetric structure with respect to the vertical transition path 231.

Next, the front case 400 will be described below with reference to FIGS. 1, 4, and 5. FIGS. 4 and 5 are plan views that illustrate a front side (outer side) and a back side (inner side) of the front case 400.

The front case 400 can be made of a transparent or semi-transparent synthetic resin. As illustrated in FIGS. 4 and 5, the front case 400 includes a planar body 410 for covering the front side of the rear case 200 entirely and a wall portion 420 for alignment that is formed around a circumference of the planar body 410. Further, display windows for checking the position of the first to third weights 510 to 530 are formed in the planar body 410. Namely, the front case 400 includes a first display window 431 for displaying detection of the first drop, a second display window 432 for displaying detection of the second drop, a third display window 433 for displaying detection of rightward tilt, and a fourth display window 434 for displaying detection of leftward tilt. The first display window 431 is formed at a position corresponding to the first weight 510 held by the second holding members 312 and 322. The second display window 432 is formed at a position corresponding to the lower weight holding portion 238. The third display window 433 is formed at a position corresponding to the right weight holding portion 234. The fourth display window 434 is formed at a position corresponding to the left weight holding portion 235. In the present embodiment, the first display window 431 is a triangular hole. Although triangular as well, the second, third, and fourth display windows 432, 433, and 434 are not holes but are thinner portions, thinner than the other area of the planar body 410, with a polished surface to allow users to observe inside the case visually.

Further, on a surface of the planar body 410 on the side (inner side) facing the rear case 200, two vertical weight guide rails 451 and 452 corresponding to the vertical transition path 231, a right weight guide rail 453 corresponding to the right transition path 232, and a left weight guide rail 454 corresponding to the left transition path 233 are formed. Each of the weight guide rails 451 to 454 and the planar body 410 are formed as a single unit. To reduce the contact resistance between the weight guide rail and the corresponding weight, the weight guide rail is arc-shaped in a cross section on the side in contact with the weight. Further, to prevent the reverse movement of the second and third weights 520 and 530, the right and left weight guide rails 453 and 454 include return prevention projections 455 and 457, and return prevention projections 456 and 458, respectively. The return prevention projections 455, 457, 456, and 458 are respectively disposed corresponding to the return prevention projections 271, 272, 273, 274, 275, 276, 277, and 278 formed on the rear case 200.

Next, a configuration in the front case 400 for preventing the weights from moving in impact in directions not to be detected is described below.

FIG. 8 is an enlarged perspective view illustrating pawls 540 and 550 that serve as restriction portions formed in the front case 400. It is to be noted that, because the pawls 540 and 550 are symmetrical, FIG. 8 illustrates only the vicinity of the pawl 540.

Referring to FIGS. 1 and 5, the weight guide rails 453 and 454 respectively include pawls 540 and 550, serving as restricting portions, and the pawls 540 and 550 are positioned in the vicinity of the initial positions of the second weight 520 and the third weight 530, respectively.

The pawls 540 and 550 are provided in one of the rear case 200 and the front case 400 that sandwich therebetween the second and third weights 520 and 530 in the thickness direction of the second and third weights 520 and 530, thereby together forming the right transition path 232 and the left transition path 233. It is to be noted that, although the pawls 540 and 550 are provided in the front case 400 in the present embodiment, the pawls 540 and 550 may be provided in the rear case 200 instead of the front case 400. The pawls 540 and 550 respectively allow the second and third weights 520 and 530 to move only when the impact detector 100 falls in the direction to be detected and inhibit movement of the second and third weights 520 and 530 when the impact detector 100 falls in directions not to be detected. The back plate 210 of the rear case 200 and the guide rails 453 and 454 (planar body 410) of the front case 400 serve as opposing walls sandwiching therebetween the weights, on one of which the pawls 540 and 550 are provided.

In other words, the pawls 540 and 550 respectively allow the second and third weights 520 and 530 to move only when the second and third weights receive force in the direction to be detected and inhibit movement of the second and third weights 520 and 530 when the second and third weights 520 and 530 receive force in directions not to be detected.

The pawls 540 and 550 are provided in the transition paths at positions corresponding to the initial positions of the second and third weights 520 and 530, respectively. Herein, the initial positions of the second and third weights 520 and 530 mean positions thereof before the impact detector 100 detects an impact, and, as shown in FIG. 6, the third weight 530 at the initial position is in contact with the weight supporter 293 as well as the stop plate 291. Similarly, although not shown in FIG. 6, the second weight 520 at the initial position is in contact with the weight supporter 292 as well as the stop plate 291.

Referring to FIG. 8, in the present embodiment, the pawl 540 includes a sloped surface 541 and a flat surface 542. The sloped surface 541 is sloped to increase the amount of projection from the planar body 410 (i.e., height of the pawl 540) toward downstream in the direction in which the weight 520 moves when detecting rightward tilt, and the flat surface 542 is continuous with the upper end of the sloped surface 541. In other words, the sloped surface 541 is sloped in a direction to reduce the right transition path 233 in size in the direction of thickness of the weight 520 toward downstream in a weight transition direction in which the weight 520 moves when the case receives the impact in the predetermined direction (i.e., to the right in FIG. 1). Similarly, the pawl 550 includes a sloped surface 541 and a flat surface 542 although not shown. The sloped surfaces 541 and 551 of the pawls 540 and 550 are configured to facilitate movement of the second weight 520 and the third weight 530, respectively, in lateral fall of the packaged article to be detected. The sloped surface 541 and the flat surface 542 of the pawl 540 together form a

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corner **540a** therebetween. Similarly, the sloped surface **551** and the flat surface **552** of the pawl **550** together form a corner **550a** therebetween although not shown in the drawings. Additionally, referring to FIG. 10A, the amount of projection of the pawls **540** and **550** at the corners **540a** and **550a**, that is, a downstream portion of the pawls **540** and **550** in the weight transition direction, is set so that a height h . That is, the right transition path **232** and the left transition path **233** are only slightly greater in the direction of thickness of the weights **520** and **530** than the thickness H of the weights **520** and **530**.

FIGS. 10A through 10C are schematic diagrams illustrating the pawl **540** viewed in the direction indicated by arrow D shown in FIG. 6.

In the present embodiment, when the packaged article falls to the front side, that is, to the side of the front case **400**, although the second and third weights **520** and **530** are about to move, a force in a direction perpendicular to the transition paths (planer body **410** shown in FIG. 8) acts on the second and third weights **520** and **530**, causing the second and third weights **520** and **530** to jolt or vibrate as shown in FIGS. 10B and 10C. Then, the second and third weights **520** and **530** respectively contact the sloped surfaces **541** and **551** or the corners **540a** and **550a** of the pawls **540** and **550** and are prevented from moving further along the right transition path **232** and the left transition path **233**. Thus, malfunction of the impact detector **100** (erroneous detection) can be prevented. By contrast, when the packaged article falls in the direction to be detected, the second and third weights **520** and **530** are respectively kept in contact with the first holding members **311** and **321** while moving, guided by the sloped surfaces **541** and **551** of the pawls **540** and **550**. Thus, the second and third weights **520** and **530** respectively move through the right transition path **232** and the left transition path **233**.

The second and third weights **520** and **530** respectively tend to engage the corners **540a** and **550a** of the pawls **540** and **550** and can be stopped easily. Additionally, when the second and third weights **520** and **530** contact the flat surfaces **542** and **552**, respectively, contact resistance therebetween inhibits movement of the second and third weights **520** and **530**. The flat surfaces **542** and **552** may be substantially in parallel to the guide rail **453** or the planar body **410**. Thus, the movement of the second and third weights **520** and **530** can be restricted effectively.

Upon impact in the direction to be detected, the second weight **520** can slide between the weight guide rail **453** (shown in FIG. 5) formed in the front case **400** and the right weight guide rails **263** and **264** formed in the rear case **200**, guided by the sloped surface **541** of the pawl **540**. Similarly, upon the direction to be detected, the third weight **530** can slide between the weight guide rail **454** (shown in FIG. 5) formed in the front case **400** and the left weight guide rails **265** and **266** formed in the rear case **200**, guided by the sloped surface **551** of the pawl **550**.

In the present embodiment, the pawls **540** and **550** are positioned close to the initial positions of the second weight **520** and the third weight **530**, respectively. If the pawls **540** and **550** are positioned away from the initial positions of the second weight **520** and the third weight **530**, respectively, oscillation of the second weight **520** and the third weight **530** in the transition paths can converge. In such a state, it is possible that the second weight **520** and the third weight **530** override the sloped surfaces **541** and **551** of the pawls **540** and **550**, resulting in erroneous detection, that is, malfunction of the impact detector **100**. Therefore, such an arrangement is not desirable.

Table 1 shows result of an experiment that was performed to check occurrence of erroneous detection in two types of

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impact detectors attached to a cardboard box when the cardboard box fell in the detection to be detected and is dropped. Type 1 has the configuration of the present embodiment in which the pawls **540** and **550** (hereinafter "lower pawls") are respectively provided close to the initial positions of the second and third weights **520** and **530**, and type 2 is a comparative example that includes pawls (hereinafter "upper pawls") respectively disposed at upper positions away from the initial positions of the second and third weights **520** and **530**.

The experiment was performed a dozen times, and "Bad" and "Good" were marked in table 1 when erroneous detection occurred and when erroneous detection did not occur, respectively.

TABLE 1

	Type 1 (Lower pawls)		Type 2 (Upper pawls)	
	Left	Right	Left	Right
1	Good	Good	Good	Good
2	Good	Good	Good	Good
3	Good	Good	Good	Good
4	Good	Good	Good	Good
5	Good	Good	Good	Good
6	Good	Good	Good	Good
7	Good	Good	Good	Good
8	Good	Good	Good	Good
9	Good	Good	Good	Good
10	Good	Good	Good	Good
11	Good	Good	Good	Good
12	Good	Good	Bad	Bad

As shown in table 1, in type 1 that includes the lower pawls respectively positioned close to the initial positions of the second and third weights **520** and **530**, the second and third weights **520** and **530** respectively disposed on the right and the left did not detect impact erroneously. By contrast, in type 2 that includes the upper pawls respectively positioned away from the initial positions of the second and third weights **520** and **530**, erroneous detection occurred. From the results of the experiments, it is confirmed that disposing the pawls **540** and **550** closer to the second and third weights **520** and **530**, respectively, is effective.

As described above, the closer the pawls **540** and **550** to the initial positions of the second and third weights **520** and **530**, respectively, the more easily the vibrating second and third weights **520** and **530** contact the pawls **540** and **550**, respectively, thus attaching higher effects. However, if the pawls **540** and **550** are respectively so close to the initial positions of the second and third weights **520** and **530** that the sloped surfaces **541** and **551** of the pawls **540** and **550** respectively overlap the second and third weights **520** and **530** at the initial positions, the second and third weights **520** and **530** might move along the sloped surfaces **541** and **551** when the cardboard box falls to the side of the front case **400**. For this reason, it is preferred that the inclination of the sloped surfaces **541** and **551** be relatively great so that the pawls **540** and **550** can be disposed close to the respective initial positions of the second and third weights **520** and **530** while avoiding the overlap between the pawls **540** and **550** and the second and third weights **520** and **530**. However, if the inclination is extremely great, it is possible that the sloped surfaces **541** and **551** might obstruct rolling of the second and third weights **520** and **530** when the cardboard box falls in the direction to be detected, thus hindering proper impact detection. In view of the foregoing, it is preferable that the pawls **540** and **550** have a length similar to the radius of the weights, for example.

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Additionally, the planar body **410** includes cylindrical pressing members **461** and **462** to be fit in the arc-shaped members **267** and **268** formed on the back plate **210** of the rear case **200**, respectively. When the front case **400** is attached to the rear case **200**, the pressing members **461** and **462** are inserted in the arc-shaped members **267** and **268**, respectively. Thereby, the right planar member **310** supported by the first right supporting member **241** and the left planar member **320** supported by the first left supporting member **242** are fixed with their end portions for holding the weight **510** positioned lower than a center portion of the rear case **200**. Herein, referring to FIGS. **5** and **8**, the pressing members **461** and **462** respectively include tilted portions **461a** and **462a** although FIG. **8** illustrates only a right portion of the front case **400**, with the pressing members **461** omitted. Thereby, the assembling accuracy of the front case **400** and the rear case **200** with the right and left planar members **310** and **320** attached thereto can be improved.

Further, as illustrated in FIG. **4**, screw holes **471** and **472** are formed in the planar body **410** of the front case **400** for screws for fixing the front case **400** to the rear case **200**. Further, insertion holes **481** and **482** are formed in the planar body **410** of the front case **400** for a fixing member for fixing the first to third weights **510** to **530**. For example, the weight fixing member is a metal wire bent to have three leg portions. When the impact detector **100** is not used, the leg portions are inserted in the first display window **431** and the insertion holes **481** and **482** and placed in contact with a lower portion of the first weight **510** and respective upper portions of the second and third weights **520** and **530**. Thereby, the first to third weights **510** to **530** are fixed, and thus the impact detector **100** is inactivated (a non-detection state). Additionally, holes **491** and **492** are formed in the planar body **410** for aligning a sealing member **740** described later (see FIG. **12A**), and recessed portions **493**, **494**, **495**, and **496** for preventing sink marks caused by the return prevention projections **455**, **457**, **456**, and **458** in the production of the front case **400**.

Next, a detailed structure of the rear case **200** will be described on the basis of FIGS. **6** and **7**. The rear case **200** of the impact detector **100** according to the present embodiment has a bilaterally symmetric shape. Therefore, FIGS. **6** and **7** illustrate only a left part of the rear case **200** for simplicity. Screw holes **241d** and **242d** are respectively formed in center portions of the first right supporting member **241** and the first left supporting member **242** to screw the front case **400** to the rear case **200**. The screw hole **241** is surrounded by a small cylindrical screw fixing boss. Further, the first right supporting member **241** includes a sandwiching projection **241a** and contact projections **241b** and **241c**, each of which has a semi-circular cross section and projects from the circumference of the screw fixing boss. The sandwiching projection **241a** of the first right supporting member **241** and the pressing member **461** formed in the front case **400** together fix the second end portion of the planar elastic member (right planar member **310**). Similarly, the first left supporting member **242** includes a sandwiching projection **242a** and contact projections **242b** and **242c**, each of which has a semicircular cross section and projects from the circumference of a small cylindrical screw fixing boss surrounding the screw hole **242d**. The sandwiching projection **242a** of the first right supporting member **242** and the pressing member **462** formed in the front case **400** together fix the second end portion of the planar elastic member (left planar member **320**). With this reduction in diameter of the first right supporting member **241** and the first left supporting member **242** serving as the screw fixing bosses, the torque required to tighten the screws can be reduced.

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Accordingly, poor screw tightening can be prevented or reduced, and the assembling work efficiency can be improved.

Additionally, the arc-shaped members **268** and **267** respectively include guide surfaces **268a** and **267a**, formed on respective outer circumferences thereof to guide the third weight **530** and the second weight **520**, and guide surfaces **268c** (shown in FIG. **9**) and **267c** formed on respective inner circumferences thereof to guide the pressing members **462** and **461**, respectively. Moreover, the arc-shaped members **268** and **267** include tilted surfaces **268b** and **267b**, respectively. The tilted surfaces **268b** and **267b** respectively facilitate insertion of the left planar member **320** between the first left supporting member **242** and the arc-shaped member **268** and insertion of the right planar member **310** between the first right supporting member **241** and the arc-shaped member **267** when the left and right planar members **320** and **310** are attached to the rear case **200**. Herein, referring to FIG. **6**, an end portion of the arc-shaped member **268** do not project from an extension line (a broken line **L** in FIG. **8**) of the first holding member **321**. Similarly, an end portion of the arc-shaped member **267** does not project from an extension line of the first holding member **311** although not shown in FIG. **6**. With this configuration, a gap **T1** between the arc-shaped member **268** and the first holding member **321** of the left planar member **320** is smaller than the diameter of the third weight **530**. Thereby, the third weight **530** is prevented from being caught by the gap **T1** when moving to the upper-left in FIG. **6** from the first holding member **321** to the end portion of the arc-shaped member **268**.

Next, the right and left planar members **310** and **320** will be described below.

In the present embodiment, the right planar member **310** is constructed of a thin stainless steel plate having a width of, for example, approximately 6 mm and a thickness of, for example, approximately 0.3 mm, and is bent at both ends of the folded portion **313**, thereby forming the first holding member **311** (arm portion) and the second holding member **312** (arm portion) with an upper portion and a lower portion of the plate, respectively. Similarly, the left planar member **320** is constructed of a thin stainless steel plate having a width of approximately 6 mm and a thickness of approximately 0.3 mm, for example, and is bent at both ends of the folded portion **323**, thereby forming the first holding member **321** (arm portion) and the second holding member **322** (arm portion) with an upper portion and a lower portion of the plate, respectively. In the configuration shown in FIGS. **6** and **7**, the second end portions of the right planar member **310** and the left planar member **320** are clamped with the folded portions **313** and **323** in contact with the sandwiching projection **241a** of the first supporting member **241** and a sandwiching projection **242a** of the first supporting member **242**, respectively, and then the pressing members **461** and **462** of the front case **400** are inserted in and pressed by the arc-shaped members **267** and **268**, respectively. Further, the first holding members **311** and **321** are in contact with and fixed by the contact projections **241b** and **242b**, respectively, and the second holding members **312** and **322** are in contact with and fixed by the contact projections **241c** and **242c**, respectively. It is to be noted that, the right and left planar members **310** and **320** may be formed of phosphor bronze when minor adjustment of the resilience force of the right and left planar members **310** and **320** is required. Alternatively, the right and left planar members **310** and **320** may be made of a resin such as nylon if it is necessary to prevent the formation of rust for long-term storage reliably.

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As illustrated in FIG. 6, when the left planar member 320 is attached to the rear case 200, the folded portion 323 is in contact with and held by the sandwiching projection 242a, and the first holding member 321 and the second holding member 322 are in contact with and held by the contact projections 242b and 242c, respectively. When the front case 400 is attached to the rear case 200 in this state, the pressing member 462 of the front case 400 is inserted in the arc-shaped member 268 and in contact with the folded portion 323. Thereby, the folded portion 323 is sandwiched and fixed by the pressing member 462 and the sandwiching projection 242a. It is to be noted that, in consideration of the tolerances of the components and the arrangement in which the sandwiching projection 242a and the pressing member 462 are provided to different members, the sandwiching projection 242a and the pressing member 462 can have dimensional errors. Therefore, it is possible that the pressing member 462, the sandwiching projection 242a, and the folded portion 323 are not in close contact with one another practically in some cases. However, because the first holding member 321 and the second holding member 322 of the left planar member 320 are in contact with the contact projections 242b and 242c, respectively, the left planar member 320 can be held reliably in the rear case 200. In this specification, the state in which “the right and left planar members 310 and 320 are clamped” includes a state in which the components are not fully in contact with one another due to slight gaps formed therebetween as in the description above.

Herein, when the front case 400 is attached to the rear case 200 by sliding the pressing member 462 along the guide surface 268c of the arc-shaped member 268, if the position of the folded portion 323 is shifted to the arc-shaped member 268, the folded portion 323 and the pressing member 462 interfere with each other, and thus the front case 400 cannot be attached to the rear case 200.

Therefore, in the present embodiment, the tilted portion 462a is formed in the edge portion of the pressing member 462 on the side facing the folded portion 323. Even if the folded portion 323 is shifted to the arc-shaped member 268, the folded portion 323 can be guided along the tilted portion 462a, after which the position of the pressing member 462 on the side of the arc-shaped member 268 is regulated by the guide surface 268c.

Then, the folded portion 323 is moved to the sandwiching projection 242a by a cylindrical portion 462b of the pressing member 462 disposed beneath the tilted portion 462a in FIG. 8. Therefore, the folded portion 323 can be sandwiched by the cylindrical portion 462b of the pressing member 462 and the sandwiching projection 242a.

Next, description will be made of the state of the left planar members 310 and 320 when the impact detector 100 receives a vertical impact.

When the impact detector 100 receives a vertical impact, the first weight 510 is disengaged from the first holding member 321 and moves downward. More specifically, the first weight 510 moves while pushing downward end portions (i.e., a points of action) of the first holding members 311 and 321 of the right and left planar members 310 and 320 in contact with the first weight 510. In this process, because each of the right and left planar members 310 and 320 is held at three points, a center portion of each of the folded portions 313 and 323 is not deformed, but the first holding members 311 and 321 deform at positions in contact with the contact projection 241b and 242b serving as fulcrums. Accordingly, the detection accuracy can be improved. Additionally, in the present embodiment, the entirety left planar member 320 is formed into a substantially angled U-shape, and the folded

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portion 323 is not curved but is linear. With the left planar member 320 that is substantially angled U-shaped, the distance of the gap T1 (shown in FIG. 6) between the end portion of the arc-shaped member 268 and the folded point between the first holding member 321 and the folded portion 323 can be reduced. The right planar member 310 is configured similarly. As a result, the third weight 530 can move smoothly without being caught in the gap between the first holding member 321 and the arc-shaped member 268.

As illustrated in FIG. 2, the first holding member 311 of the right planar member 310 attached to the rear case 200 has an effective spring length (indicated by double-headed arrow a shown in FIG. 2, hereinafter “effective spring length a”) that extends from a point of contact between the first holding member 311 and the first supporting member 241 to a lower end of the first holding member 311. Similarly, an effective spring length of the first holding member 321 extends from a point of contact between the first holding member 321 and the first supporting member 242 to a lower end of the first holding member 321. Further, an effective spring length (indicated by double-headed arrow b shown in FIG. 2, hereinafter “effective spring length b”) of the second holding member 312 extends from a point of contact between the second holding member 312 and the second supporting member 251 to a lower end of the second holding member 312. Similarly, an effective spring length of the second holding member 322 extends from a point of contact between the second holding member 322 and the second supporting member 252 to a lower end of the second holding member 322. In the present embodiment, the effective spring lengths a and b are identical or similar and approximately 20 mm, for example. Additionally, in the present embodiment, a gap between the first holding members 311 and 321 (indicated by double-headed arrow c shown in FIG. 2, hereinafter “gap c”) and a gap between the second holding members 312 and 322 (indicated by double-headed arrow d shown in FIG. 2, hereinafter “gap d”) are identical or similar. Therefore, two impacts of the same magnitude can be detected with the use of the same first weight 510.

Further, in the present embodiment, each of the first holding members 311 and 321 and the second holding members 312 and 322 forms an angle θ , which is smaller than 90 degrees, with the vertical transition path 231. The angle θ may be 45 degrees, for example. As described above, the first holding members 312 and 322 on the upper side serve as the lower guide member for guiding the second weight 520 moving through the right transition path 232 and the lower guide member for guiding the third weight 530 moving through the left transition path 233, respectively. Therefore, a threshold of angle of tilt is set with the above-described angle θ . Herein, the angle θ affects the sensitivity level of the impact detection using the first weight 510 in addition to determining the threshold angle of tilt to be detected. In the present embodiment, the angle θ is set to 45 degrees, considering that the packaging container, to which the impact detector 100 is attached, is rectangular parallelepiped generally.

The magnitude of drop impact to be detected and the accuracy thereof are determined by factors including, in addition to the above-described angle θ , a variety of characteristics of the planar members 310 and 320, such as the material, the cross-sectional shape, the effective spring lengths a and b, the distance of the gap c between the end portions of the first holding members 311 and 321, and the distance of the gap d between the end portions of the second holding members 312 and 322, and the mass and the diameter of the first weight 510. In the present embodiment, the values of these factors are set on the assumption that the impact detector 100 is used for

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relatively large packaging containers. In general, impact detectors for relatively large packaging containers are generally intended to detect a drop from a relatively low position rather than a drop from a relatively high position. If the mass of the weight **510** is relatively small, it is difficult to detect impact of drop from a relatively low position unless the spring force of the first and second holding members **311**, **321**, **312**, and **322** is substantially reduced. To detect the drop impact from a relatively low position by using relatively light weights, holding members having relatively small spring force are required. In this case, the detection accuracy is deteriorated. The fluctuation in the detection accuracy can be caused by friction or engagement between the weight **510** and the first and second holding members **311**, **321**, **312**, and **322**, deformation of the folded portions **313** and **323**, and the like.

In view of the above, the present embodiment uses a weight having a certain amount of mass as the weight **510**. For example, in the present embodiment, the weight **510** is a tablet-like stainless steel weight having a circular periphery, a diameter of approximately 10 mm, a thickness of approximately 6 mm, and a mass of approximately 3.7 g. Preferably, the weight **510** is chamfered to prevent the friction and engagement with the first and second holding members **311**, **321**, **312**, and **322**. The outer surface of the weight **510** may exhibit the color of the metal forming the weight. Alternatively, the weight may be colored at least partly differently from other components or marked with a sticker to improve the visibility. The material of the weight **510** preferably has a relatively high specific gravity such as stainless steel because the thickness and size of the weight can be reduced in that case, resulting in the reduction in the size of the impact detector **100**. As the material forming the weight, other metals such as aluminum, for example, may also be used.

Herein, the specifications of the right and left planar member **310** and **320** required to detect a drop impact from a predetermined height with a predetermined weight can be obtained by calculation. More specifically, the amount of deformation of a leaf spring (first and second holding members **311**, **321**, **312**, and **322**) made of a predetermined material, having a predetermined cross-sectional shape, caused by impact energy from a predetermined height is calculated, and a necessary effective spring length is derived based on the calculated amount of deformation. Based on the calculation above, the respective dimensions of the first holding members **311** and **321** and the second holding members **312** and **322** are determined. It is to be noted that, if the effective length of the leaf spring is shorter compared with the diameter of the weight **510**, the weight **510** cannot be separated from the leaf spring unless the amount of displacement (deformation) of the leaf spring is increased. However, increasing the amount of deformation of the leaf spring can increase the length of the end portion of the leaf spring in contact with the weight **510** and the time of contact therebetween. As a result, the leaf spring and the weight **510** engage with each other, and the weight **510** supported by the leaf spring fails to drop in some cases. Therefore, the effective length of the leaf spring needs to be relatively long compared with the diameter of the weight **510**.

Next, operation of the impact detector **100** is described below.

FIGS. **11A** through **11E** schematically illustrate operation of the impact detector **100**.

In the initial state shown in FIG. **11A**, the first weight **510** is held by the first holding members **311** and **321**, the second weight **520** is held by the stop plate **291** and the weight supporter **292**, and the third weight **530** is held by the stop plate **291** and the weight supporter **293**. The first to third

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weights **510** to **530** are not visually observed through any of the display windows **431** to **434** in the initial state.

Upon an initial vertical drop (first drop) from the initial state, the first weight **510** pushes away the first holding members **311** and **321** from each other, drops, and then is held by the second holding members **312** and **322** as shown in FIG. **11B**. Thereby, the first weight **510** is visually observable through the first display window **431**.

Upon a rightward tilt from the state shown in FIG. **11B**, the second weight **520** rolls rightward in FIG. **11C**, guided by the upper surface of the first holding member **311** of the right planar member **310**, drops along the right transition path **232**, and then is held by the right weight holding portion **234** as shown in FIG. **11C**. In this state, the second weight **520** is visually observable through the third display window **433**.

Upon a subsequent vertical drop (second drop) from the state shown in FIG. **11C**, the first weight **510** pushes away the second holding members **312** and **322** from each other, drops, and then is held in the lower weight holding portion **238** as shown in FIG. **11D**. Thereby, the first weight **510** is visually observable through the second display window **432**. Thus, in the present embodiment, the impact caused by the drop can be detected twice with a single impact detector.

Upon a leftward tilt from the state shown in FIG. **11D**, the third weight **530** rolls leftward in FIG. **11E**, guided by the upper surface of the first holding member **321** of the left planar member **320**, drops through the left transition path **233**, and then is held in the left weight holding portion **235** as shown in FIG. **11E**. In this state, the third weight **530** is visually observable through the fourth display window **434**.

As described above, according to the present embodiment, the first to third weights **510** to **530** are visually observable through the display windows **431** to **434** in accordance with the first and second drops and the rightward and leftward tilts. Accordingly, the history of impact of drops and tilts of the impact detector **100** can be displayed with the first to third weights **510** to **530** visible through the display windows **431** to **434** of the impact detector **100**.

Next, conjunction of the projections **221** through **226** with the pawls **540** and **550** is described below. When the packaging container including the impact detector **100** falls backward, that is, to the side of the rear case **200**, movement of the second and third weights **520** and **530** is restricted as follows. When the jolting (vibration) of the second and third weights **520** and **530** are relatively great, as described above with reference to FIG. **10A** through **10C**, the second and third weights **520** and **530** respectively contact the pawls **540** and **550**, and thus movement of the second and third weights **520** and **530** is restricted. By contrast, when jolting of the second and third weights **520** and **530** is relatively small, it is possible that the second and third weights **520** and **530** can slide on the sloped surfaces **541** and **551** of the pawls **540** and **550** or do not contact the pawls **540** and **550** and pass thereby, respectively. However, at that time, the second and third weights **520** and **530** can be stopped by the projections **221** through **223** and the projections **224** through **226** that are respectively provided downstream from the pawls **540** and **550** in the right transition path **232** and the left transition path **233**. Thus, the second and third weights **520** and **530** do not move further also in this case. When the packaging container is returned to the initial state from the forward fall, the second and third weights **520** and **30** do not jolt but return to the respective initial positions along the right weight guide rails **263** and **264** and the left weight guide rails **265** and **266**, respectively.

By contrast, when the packaging container falls forward, that is, to the side of the front case **400**, circumferential edge portions of the second and third weights **520** and **530** respec-

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tively engages bottom portions of the sloped surfaces **541** and **551** of the pawls **540** and **550**, and thus the second and third weights **520** and **530** stop. When the packaging container receives vertical impact, that is, falls from its lower corner, movement of the second and third weights **520** and **530** can be restricted as well in either of two manners depending on the magnitude of the impact. Therefore, in either case, erroneous detection can be prevented.

Next, a packaging container according to an embodiment of the present invention will now be described below with reference to FIGS. **12A** through **12C**.

FIGS. **12A** through **12C** are schematic diagrams illustrating a packaging container including the impact detector **100**. FIG. **12A** is a perspective view illustrating the packaging container, FIG. **12B** is a perspective view illustrating the impact detector **100** attached to the packaging container shown in FIG. **12A**, and FIG. **12C** is a cross-sectional view illustrating the attached state of the impact detector **100**.

Referring to FIG. **12A**, a packaging container **700** according to the present embodiment includes a cardboard box **710** having a side surface **720** on which the impact detector **100** is attached. An opening **730** can be formed in the side surface **720** of the cardboard box **710** so that the impact detector **100** can fit in the opening **730** and attached to a vertical plane of an object stored in the packaging container **700**.

To fit the impact detector **100** in the side surface **720** of the cardboard box **710**, it is preferred that the rear case **200** should include the flange portion **240** and that the front case **400** should include overhang portions **480** as well as a lower projecting portion **490** as illustrated in FIG. **12B**. With this configuration, a lower portion of the impact detector **100** is inserted in the opening portion **730** such that the flange portion **240** and the lower projecting portion **490** sandwich a lower edge portion **720a** of the opening portion **730** as shown in FIG. **12C**, and the overhang portions **480** is closely in contact with the outer surface of the side surface **720**. Thereafter, the sealing member **740** is attached to cover the impact detector **100**. Thereby, the impact detector **100** is reliably attached to the packaging container **700**. Further, it is possible to prevent falsification, i.e., to prevent someone from removing the impact detector **100** from the cardboard box **710** and resetting the weights to the initial state when the cardboard box **710** receives an impact. In this case, it is preferred that an adhesive surface of the sealing member **740** includes a material containing glue so that the glue can be partly transferred and adheres to the surface of the front case **400** when the sealing member **740** is removed. Thereby, it is possible to check whether or not the impact detector **100** has been unsealed for falsification.

An impact detector according to a second embodiment is described below.

FIG. **13** is a schematic view illustrating an impact detector **800** according to the second embodiment.

The impact detector **800** includes a leaf spring **310A** and a weight **510**, both disposed inside a case **200A**, and an interior of the case **200A** and the leaf spring **310A** together form a vertical transition path through which the weight **510** moves down when the case **200A** is subjected an impact in a vertical direction as well as lateral transition paths through which the weight **510** moves when the case **200A** is subjected to an impact in a direction oblique to the vertical direction. The impact detector **800** displays history of the impact to the packaged article with the position of the weight **510**. The leaf spring **310A** includes free ends **310A1** and projections **310A2** and **310A3** so that the position of the weight **510** in the vertical transition path can differ depending on the magnitude of the impact.

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When the impact in the vertical direction, that is, the impact from below is relatively small, the weight **510** remains at an initial position supported by the upper projections **310A3** of the leaf spring **310A**. By contrast, when the impact from below is sufficiently great for the weight **510** to push away the projections **310A3** from each other, the weight **510** expands the gap between the projections **310A3**, moves down, and then is caught between the lower projections **310A2**. When the impact is greater, the weight **510** further pushes away the lower projections **310A2** from each other and moves down to the bottom of the case **200A**. At that position, the weight **510** is visible through an inspection window (not shown) formed in a bottom portion of the case **200A**. Additionally, with the projections **310A2**, the weight **510** does not move toward the initial position. By contrast, when the packaged article falls in a lateral direction, the weight **510** moves through the lateral transition path, beyond a curved portion of the leaf spring **310A**, and stops on a lower left or right of the leaf spring **310A** in FIG. **13**.

The impact detector **800** further includes pawls **810** and projections **820**. The pawls **810** are disposed close to the initial position of the weight **510** and have a configuration similar to that in the first embodiment. The projections **820** are disposed on the left and the right of an upper center portion **830**, respectively. In the present embodiment, although pawls **810** and the projections **820** prevent the weight **510** from moving when the impact detector **800** receives impact that is not to be detected, the weight **510** can move smoothly when the impact detector **800** is dropped or falls laterally similarly to the first embodiment. Thus, the history of impact in the predetermined directions can be displayed.

An impact detector according to a third embodiment is described below.

FIG. **14** is a plan view from a front side illustrating an impact detector **900** according to the third embodiment.

The impact detector **900** according to the present embodiment has a configuration similar to the left half of the impact detector **100** according to the first embodiment described above, and is similar to the impact detector **100** according to the first embodiment in other configurations. Therefore, the corresponding components are given the identical reference characters, and description thereof is omitted.

In the present embodiment, the first weight **510** is held by the left planar member **320** and a wall portion **910** of a rear case **200B**. Upon a drop impact, the first weight **510** moves through the vertical transition path **231** while deforming the first holding member **321** and the second holding member **322**. Additionally, upon a tilt to one side (to the left in FIG. **14**), the third weight **530** moves through the left transition path **233**. Thus, the impact detector **900** can detect two drops and a tilt to one side with a simple configuration.

An impact detector according to a fourth embodiment is described below.

FIG. **15** is a schematic view illustrating an impact detector **1100** according to the fourth embodiment.

The impact detector **1100** according to the present embodiment includes a circular planar weight **1110** contained in a case **1120**, detects a fall in a single direction, and displays the fall. The case **1120** includes an initial recessed portion **1130** in which weight **1110** is held in an initial state, an lower wall **1140** on which the weight **1110** rolls, an impact detection recessed portion **1150**, and a display window **1160**. When the impact detector **1100** is tilted a predetermined angle in a counterclockwise direction in FIG. **15**, the weight **1110** moves out from the initial recessed portion **1130**, fits in the impact detection recessed portion **1150**, and is visible through

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the display window 1160. A transition path 1170 through which the weight 1110 moves is formed above the lower wall 1140.

Additionally, a pawl 1180 and a projection 1190 are provided in the case 1120. The pawl 1180 has a configuration similar to that of the pawls 540 and 550 in the first embodiment and reduces the transition path 1170 in the size in the direction of thickness of the weight 1110, thereby restricting movement of the weight 1110 when the weight 1110 vibrates. The projection 1190 is provided on an upper wall 1111 positioned above the lower wall 1140 (transition path 1170) and includes a corner 1191 positioned facing the weight 1110 held in the initial recessed portion 1130.

In the present embodiment, when the impact detector 1100 is tilted a predetermined angle in the counterclockwise direction in FIG. 15, the weight 1110 moves out from the initial recessed portion 1130 and fits in the impact detection recessed portion 1150. Additionally, when the impact detector 1100 is dropped or falls in an anteroposterior direction, the pawl 1180 and the projection 1190 prevent the weight 1110 from moving to the impact detection recessed portion 1150. Consequently, the impact detector 1100 detects impact in only the predetermined direction and does not detect impact erroneously.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

What is claimed is:

1. An impact detector comprising:
 - a weight having a circular periphery;
 - a case in which the weight is contained, an interior of which defines a transition path that connects an initial position and a detection position and through which the weight moves to the detection position with a circumferential surface of the weight in contact with the interior of the case when the case receives at least one of an impact and a force in a predetermined direction; and
 - a restriction portion projecting from the interior of the case into the transition path to restrict movement of the weight toward the detection position when the case receives at least one of an impact and a force in a direction other than the predetermined direction while the weight is in the initial position.
2. The impact detector according to claim 1, wherein the case comprises opposing walls that sandwich therebetween the weight in a direction of thickness of the weight and together form the transition path,
 - the restriction portion includes a protrusion portion provided on at least one of the opposing walls of the case, and
 - the protrusion portion allows the movement of the weight toward the detection position when the impact detector falls in a direction to be detected and inhibits the movement of the weight when the impact detector falls in a direction other than the predetermined direction.
3. The impact detector according to claim 2, wherein the protrusion portion of the restriction portion reduces the transition path in length in the direction of thickness of the weight.
4. The impact detector according to claim 2, wherein the protrusion portion of the restriction portion includes a sloped surface sloped in a direction to reduce the transition path in length in the direction of thickness of the weight toward downstream in a weight transition direction in which the

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weight moves when the case receives the at least one of the impact and the force in the predetermined direction.

5. The impact detector according to claim 4, wherein the length of the transition path in the direction of thickness of the weight at a position corresponding to the protrusion portion is greater than a thickness of the weight.

6. The impact detector according to claim 4, wherein the protrusion portion of the restriction portion further comprises a corner continuous with a downstream end of the sloped surface in the weight transition direction in which the weight moves when the case receives the at least one of the impact and the force in the predetermined direction.

7. The impact detector according to claim 6, wherein the protrusion portion of the restriction portion further comprises a surface substantially in parallel to the opposing walls, disposed downstream from the corner in the weight transition direction in which the weight moves when the case receives the at least one of the impact and the force in the predetermined direction.

8. The impact detector according to claim 2, wherein the protrusion portion of the restriction portion is disposed close to the initial position of the weight.

9. The impact detector according to claim 2, wherein a length of the protrusion portion of the restriction portion along the transition path, perpendicular to the direction of thickness of the weight, is substantially identical to a radius of the weight.

10. The impact detector according to claim 1, wherein the case comprises an upper wall and a lower wall that sandwich therebetween a circumference of the weight and together form the transition path,

the restriction portion comprises a projection provided on the upper wall, and

the projection allows the movement of the weight toward the detection position when the impact detector falls in a direction to be detected and inhibits the movement of the weight when the impact detector falls in a direction other than the predetermined direction.

11. The impact detector according to claim 10, wherein the projection of the restriction portion reduces the transition path in size in a direction perpendicular to the direction of thickness of the weight.

12. The impact detector according to claim 10, wherein the case further comprises a guide wall disposed above the initial position of the weight for guiding the weight from the initial position to the transition path, and

the projection of the restriction portion is disposed downstream from the guide wall in the direction in which the weight moves when the case receives the at least one of the impact and the force in the predetermined direction.

13. A packaging container comprising:

a container in which an article is contained; and the impact detector according to claim 1.

14. An impact detector comprising:

a weight having a circular periphery;

a case in which the weight is contained, an interior of which defines a transition path that connects an initial position and detection position, the transition path through which the weight moves to the detection position with a circumferential surface of the weight in contact with the interior of the case when the case receives at least one of an impact and a force in a predetermined direction; and a restriction means for restricting movement of the weight toward the detection position when the case receives at

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least one of an impact and a force in a direction other than the predetermined direction.

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